STARS RESOURCES

Teacher notes

Human telescope

ACTIVITY - adapted from NASA's Learning Universe 'Kinesthetic Telescope'

Model how light travels through a telescope by embodying the components.

Students will:

- explore how light travels through a telescope,
- be familiar with the dimensions of Australia's largest optical telescope, and
- understand the purpose of mirrors in modern telescopes.

This activity is aimed at Years 5 - 8 and is divided into two parts. You can elect to just complete Activity 1 or carry on to complete Activity 2 – a more advanced version. A student workbook is provided for each part.

CURRICULUM LINKS

YEAR 5 SCIENCE V.9

Physical sciences

Identify sources of light, recognise that light travels in a straight path and describe how shadows are formed and light can be reflected and refracted (AC9S5U03)

- drawing ray diagrams to show the path of light from a source reflects off surfaces into the eye
- exploring the use reflection of light by mirrors such as in periscopes and mirror mazes

Investigate how scientific knowledge is used by individuals and communities to identify problems, consider responses and make decisions (AC9S5H02)

- researching the impacts of light pollution and exploring how communities have used scientific knowledge to reduce light pollution, such as through the use of covered bulbs facing downwards in streetlight, automated systems to turn off streetlights and motion sensors on outdoor lights at home and in public places

YEAR 6 SCIENCE V.9

examine why advances in science are often the result of collaboration or build on the work of others (AC9S6H01)

- constructing a timeline to show how contributions and collaboration of scientists, mathematicians and astronomers from many countries have advanced our ideas about space and the solar system through development of models, gathering of evidence and, more recently, space exploration

BACKGROUND INFORMATION

A telescope is a device that collects and focuses light coming from a long way away, usually from space. The invention of the first telescope over 400 years ago is associated with Dutch inventor, Hans Lipperhey.

The two main telescope designs are the Newtonian and Cassegrain.

Newtonian telescope

The design named after Sir Isaac Newton is a 'reflector' telescope and works by using two mirrors to reflect light that gathers at the eyepiece forming an image (Figures 1 and 2). The Dobsonian telescope, often used by amateur astronomers, is very similar in design.

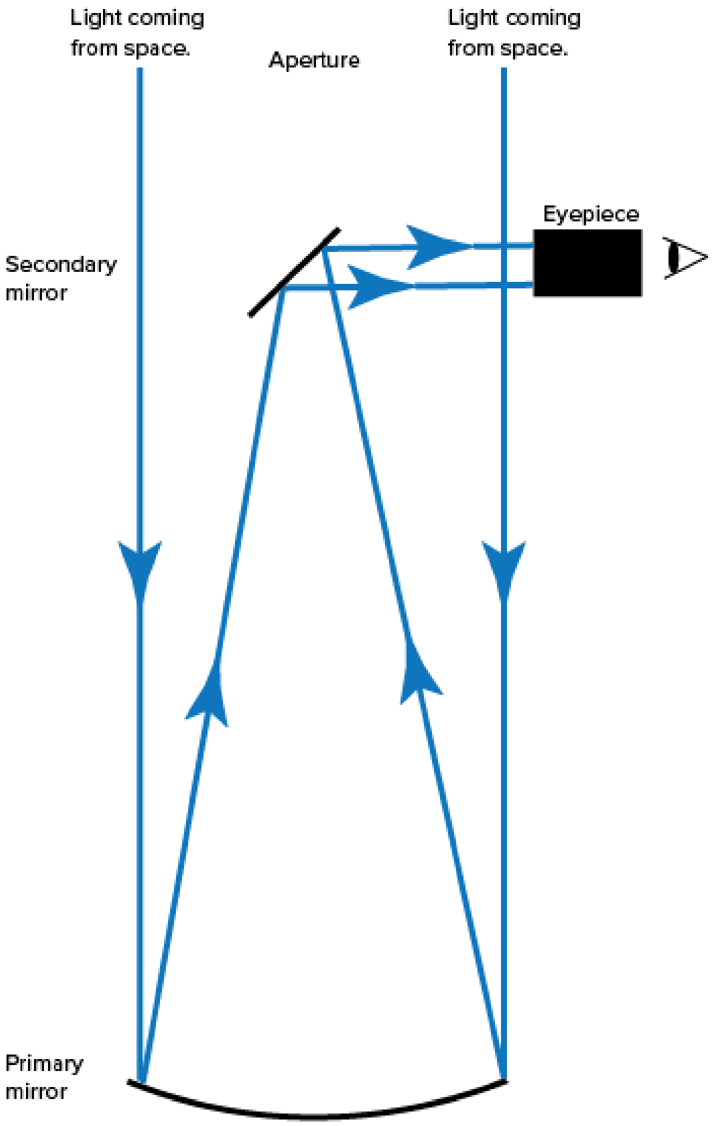


Figure 1: A simple Newtonian telescope.

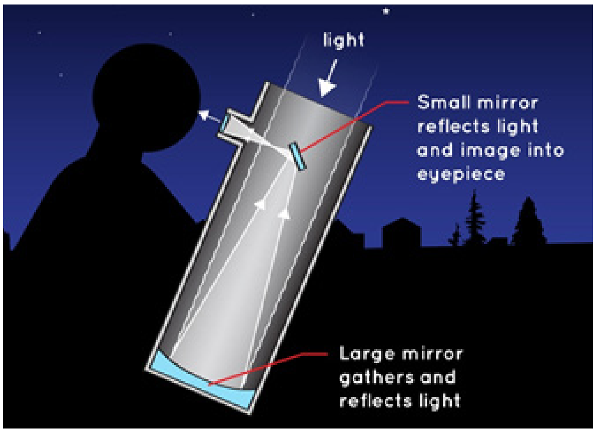


Figure 2: A Newtonian telescope showing the primary and secondary mirrors and light paths. Credit: NASA/JPL – Caltech.

BACKGROUND INFORMATION cont'd

Cassegrain telescope

The most common design is known as a Cassegrain reflecting telescope (Figure 3). The light enters the telescope at the top of the tube, travels down to the mirror at the bottom (primary mirror), bounces up to a smaller mirror partway up the tube (secondary mirror), and then reflects down through a hole in the middle of the primary mirror to the eyepiece or a detector. The focal point is behind the primary mirror.

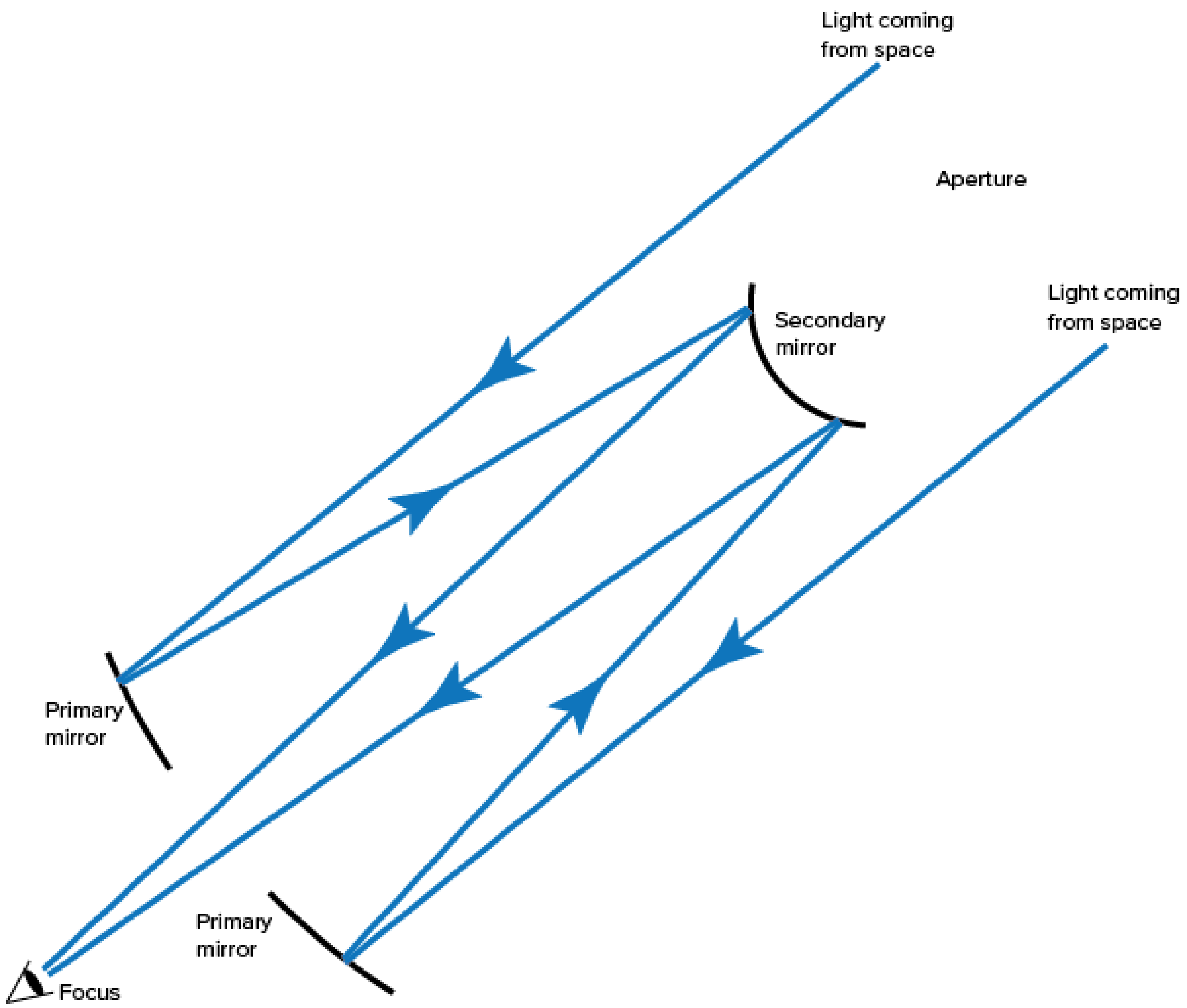


Figure 3: A simple Cassegrain telescope with two mirrors.

BACKGROUND INFORMATION cont'd

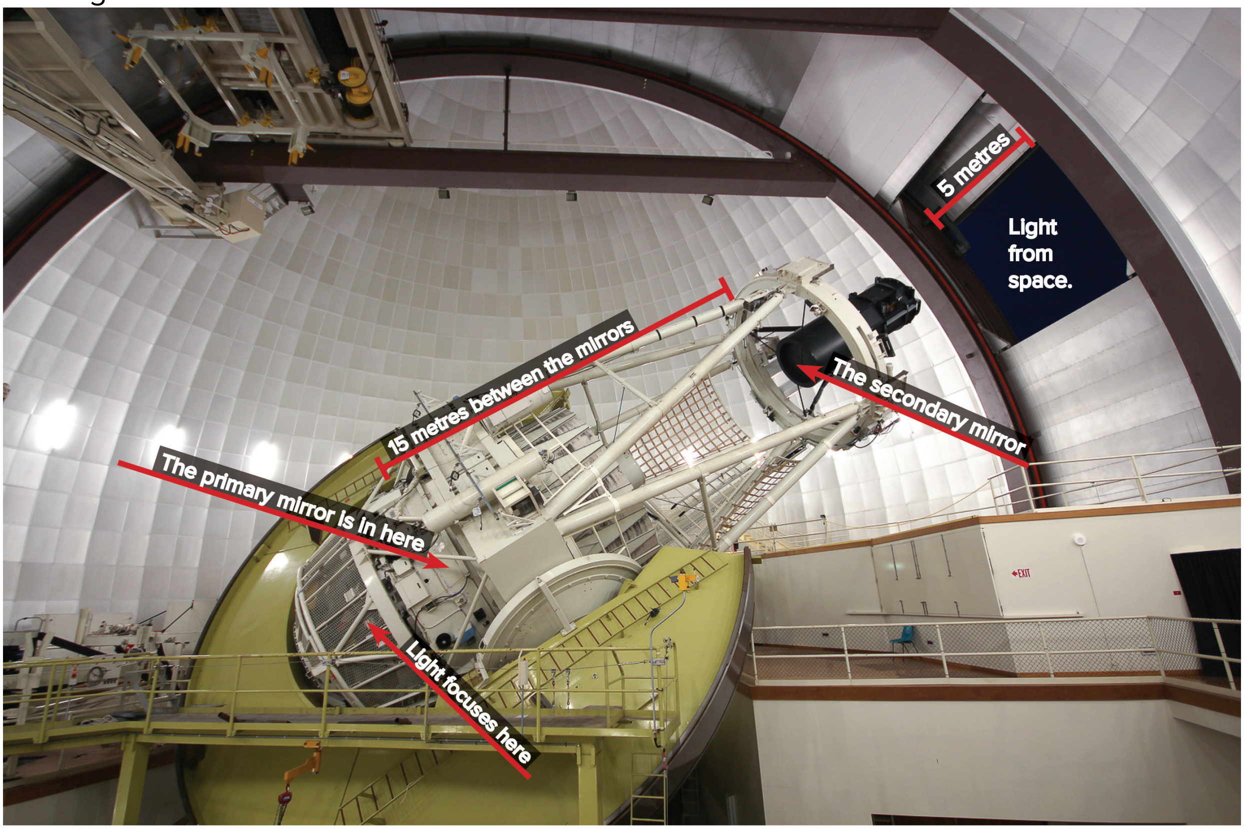
As with all complex technology, many telescope features can be modified. For instance:

- the shape of the mirrors (e.g. spherical, parabolic, hyperbolic, etc.),
- the size of the mirrors (up to 8.2 metres in diameter!)
- the distance between the primary and secondary mirrors,
- additional mirrors to send the light off in other directions,
- the material on the surface of the mirrors (e.g. silver, aluminium, gold, beryllium, etc.),
- the sort of light that you want to detect (e.g. visible, infrared, ultraviolet, radio, etc.)

AAT

The Anglo-Australian Telescope (Figure 4), Australia's largest optical telescope (i.e. designed for catching light that humans can see), has a primary mirror that is 3.9 metres across, has a square aperture that is 5 metres x 5 metres in size, has the primary and secondary mirrors separated by 15 metres, and has a focus that is two metres behind the primary mirror. The hole in the middle of the primary mirror is about one metre across. The primary mirror weighs 16 tonnes!

For comparison, the largest optical telescope in space – the James Webb Space Telescope – has a segmented mirror that is 6.5 metres across.



Source: 'The Anglo-Australian Telescope', AAT website, https://aat.anu.edu.au/about-us/AAT (Accessed June 2023)

Figure 4: Showing the main components of the Anglo-Australian Telescope in Coonabarabran, NSW.

BACKGROUND INFORMATION cont'd

Consideration of prior knowledge

Knowledge of telescopes

Students may have access to amateur telescopes at home, and so may already be familiar with telescopes. Often affordable telescopes are Dobsonians (i.e. Newtonian arrangement of mirrors), or refractors that use lenses.

Students may also be familiar with the night sky through the use of apps on smart devices. Note that the light-collecting ability of such devices is poor and that images captured through their cameras are often digitally enhanced.

This activity is focussed on optical telescopes; some students are likely to be aware of space telescopes, and radio telescopes. Consider prefacing the activity with an overview of the types of telescopes, and moving into a specific Australian example which relates to the activity.

Common misconceptions

Students may think that:

- light is not something that travels; only the source of light is considered (e.g. Sun, torch);
- our don't eyes receive any light;
- the view we see through a telescope wil not be the same as we see in pictures; and
- you can use a telescope to magnify objects as much as you like.

Links to further information

- a broad-brush introduction to the electromagnetic spectrum
  'Tour of the EMS 01 – Introduction', ScienceAtNASA YouTube (5:03 mins),
  https://youtu.be/lwfJPc-rSXw (7 May 2010)
- a specific introduction to radio waves
  'Tour of the EMS 02 – Radio Waves', ScienceAtNASA YouTube (3:38 mins),
  https://youtu.be/OzDmEA8x0nQ (11 May 2010)
- 'Optical telescopes', ESO YouTube (2:03 mins), https://youtu.be/h2WoCnBfpyc
- 'A SAMI night at the AAT', AAT website (3:34 mins),
  https://aat.anu.edu.au/public/video/a-sami-night-at-the-aat

All resources accessed June 2023.

ACTIVITY 1

Newtonian Telescope

Equipment

- Telescope vocabulary words with definitions printed onto palm-card sized paper
- Box large enough to hold the vocabulary word cards
- Telescope narration (either printed or on a portable digital device)
- Chalk (to mark concrete) or masking tape (for carpeted areas)
- Measuring tape (at least 5 metres long)
- String (optional)
- Astronomical image (e.g. the Moon, Jupiter or Pleiades cluster) printed onto A4 or A3 sheet
- Copies of student workbook

Planning ahead

1. Clear a path across your classroom or down a hallway, or you can even go outside to a flat, open area (undercover play areas are ideal).

2. Select 12 students who will form the human telescope. The teacher will be the narrator.

- 1 x Aperture
- 1 x Primary mirror
- 1 x Secondary mirror
- 1 x Focuser
- 1 x Eyepiece
- 1 x Eye/brain
- 1 x Tube
- 5 x Light

3. Remind the students on the layout of the telescope.

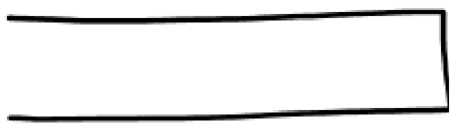
ACTIVITY 1 cont'd

Activity

1. Have each student draw a vocabulary word out of the box. Give the astronomical image to the students with the eyepiece card ensuring they keep it hidden until the end of the narration.

2. Ask each student to read their vocabulary word (and definition) aloud. Explain that each different word represents part of the process of seeing an astronomical image through a telescope.

3. Ask the student who has the 'tube' card to measure with the measuring tape, and draw this shape on the floor (approx. 2 metres wide x 5 metres long) with chalk (or tape). Ask this student to stand at the open end of the tube.



4. Ask the five students with the 'light' cards to gather at one end of the space.

5. Read out the narrator's script, moving the students into their positions (or request they find their place depending on the ability level of the participants) as you read their vocabulary word.

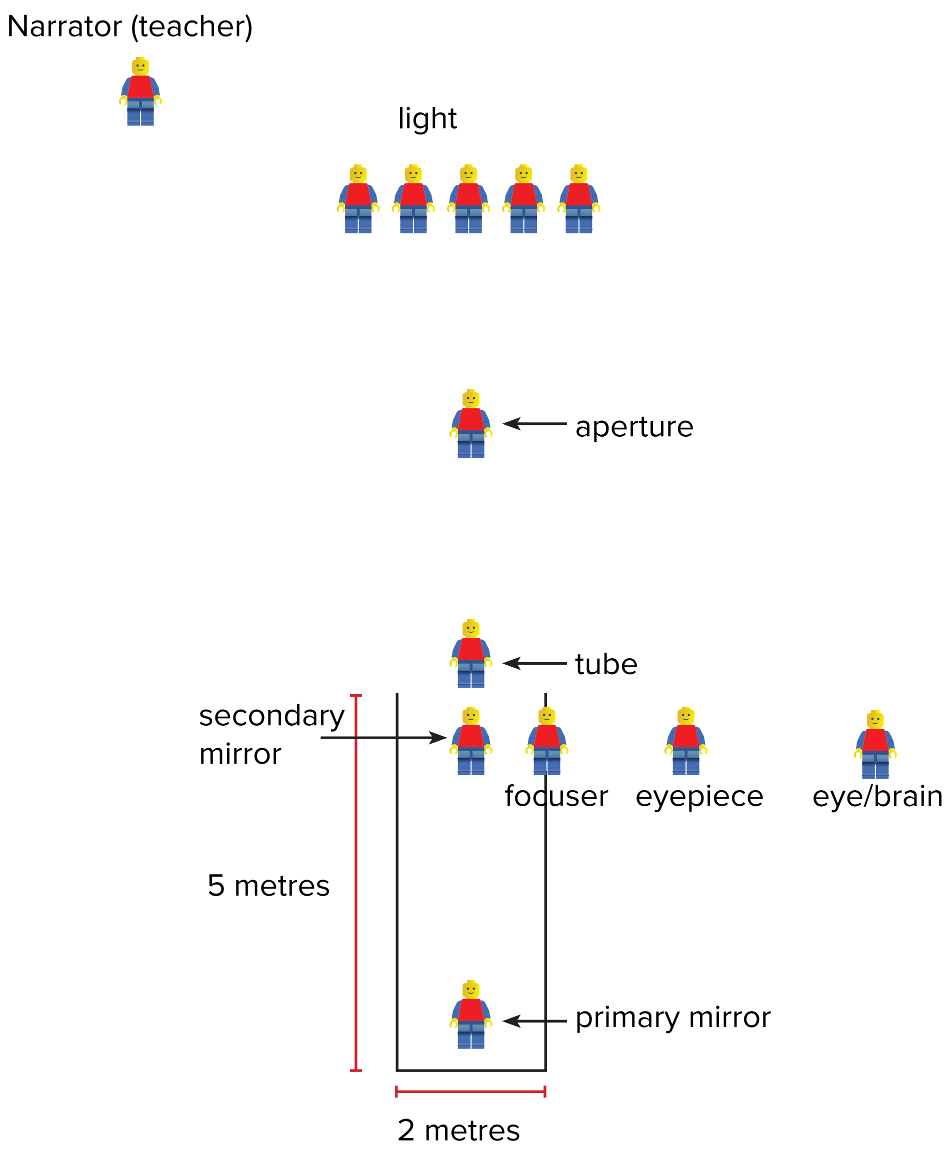
6. Demonstrate (and discuss) the path that light takes through the telescope and how each part of the telscope interacts with the light.

7. Use suggested follow-up questions to extend student learning.

8. Students can recreate the process and present the narrated sequence on their own. Each part of the telescope explains its role. NOTE: Light cannot move forward until given permission from the appropriate part of the telescope or by the narrator.

9. Provide students with a workbook each to complete.

ACTIVITY 1 cont'd



NARRATION and CARDS - ACTIVITY 1

Narrator's script.

1. Light travels from an object in space through the telescope's aperture and into the tube.

2. At the far end of the tube, the primary mirror collects and focuses the light onto the secondary mirror.

3. The secondary mirror reflects the light to an opening on the side of the tube (Note here: get the tube card holder to rub out a hole in the tube).

4. The focuser moves the eyepiece into position in line with the eye/brain.

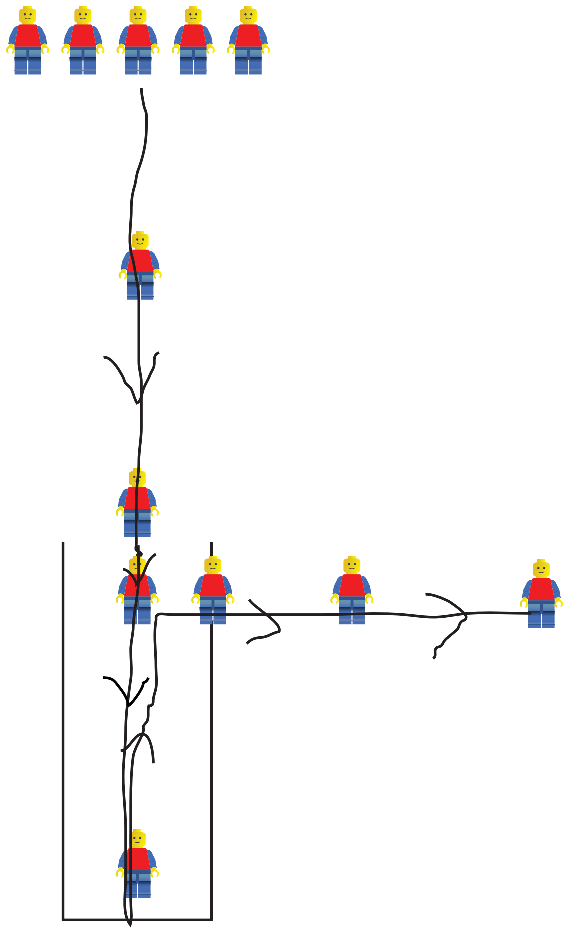
5. The eyepiece magnifies the image of the space object.

6. The human eye (with help from the brain) uses its own lens to see the astronomical image.

Eye/brain 'Sees' the image from the telescope	**Aperture** The opening of the telescope that lets the light in	**Primary mirror** Focuses light onto secondary mirror
Secondary mirror Focuses light into the eyepiece	**Light**	**Light**
Light	**Light**	**Light**
Tube The channel for the light to travel through	**Focuser** Brings the light to a focus to create an image	**Eyepiece** The place where you put your eye to see the image

ACTIVITY 1 WORKBOOK ANSWERS

1. Now that you have completed the exercise, trace out the track that the light particles took in the telescope. Use arrows to show the direction at each step.



Light is moving inside the telescope from the opening of the tube to the primary mirror, back to the secondary mirror, across past the focuser into the eyepiece to deliver the light to the human eye.

2. In a real telescope, mirrors are curved. What do you think are some advantages of using curved mirrors instead of flat mirrors?

Can control the direction of the reflected light. Can focus the light.

3. Light has the ability to reflect off surface. Keeping this in mind, suggest what material you might use on the inside of the tube to reduce reflections.

Suggestions include: anything black and matte (i.e. not shiny). Fabric, paint, etc.

4. In this activity you used five people to represent the light. How many 'pieces' of light do you think a real 2 metre telescope could collect?

Think of a big number. This is an open ended question, as it depends on many factors, including the object you're looking at, how long you look at it for, the atmospheric conditions, the particulars of the glass that has been used on the mirror, etc. But if the students choose a number that has upwards of 20 zeros on it, then they're on the right track.

ACTIVITY 2

Ango-Australian Telescope

Now try a similar but more advanced activity to embody the Anglo-Australian Telescope. Conduct this exercise in a room large enough to allow you to set things out to scale.

In this version, all of the participants (except the hole in the primary mirror) can take up position from the beginning.

Equipment

- Telescope vocabulary words with definitions printed onto palm-card sized paper
- Box large enough to hold the vocabulary word cards
- Telescope narration (either printed or on a portable digital device)
- Chalk (to mark concrete) or masking tape (for carpeted areas)
- 2 x measuring tapes
- Astronomical image (e.g. the Moon, Jupiter or Pleiades cluster) printed onto A4 or A3 sheet
- Copies of the student workbook

Planning ahead

1. Clear a path across your classroom or down a hallway, or you can even go outside to a flat, open area (undercover play areas are ideal).

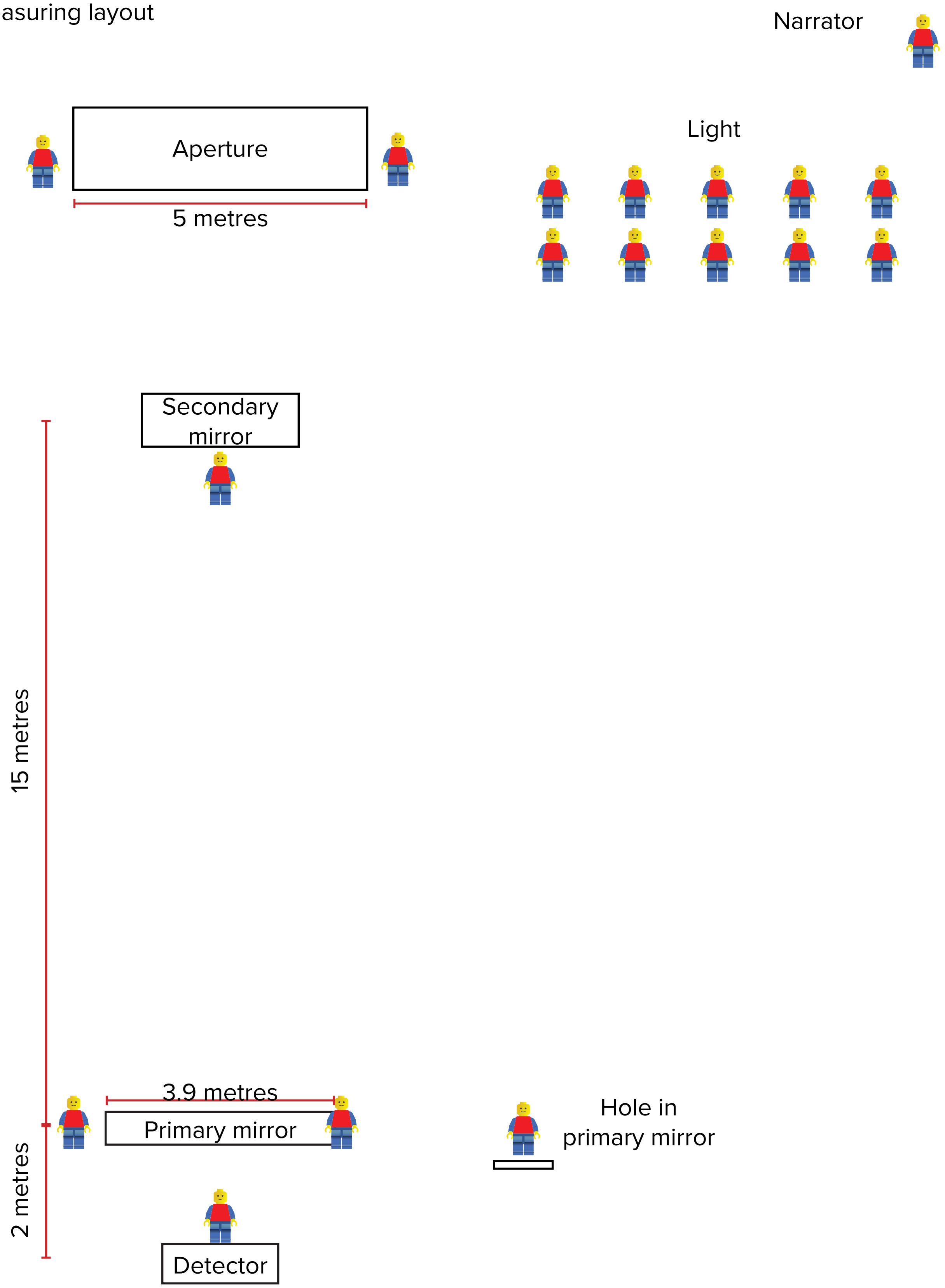
2. Remind the students of the layout of the telescope.

3. Select 19 students to be part of the human telescope and one student to be the narrator.

- 1 x Narrator
- 2 x Aperture in the dome (two people standing 5 metres apart with a measuring tape between them)
- 2 x Primary mirror (two people standing 3.9 metres apart with a measuring tape between them)
- 1 x Secondary mirror
- 1 x Hole in the primary mirror
- 1 x Detector
- 1 x Tube
- 10 x Light

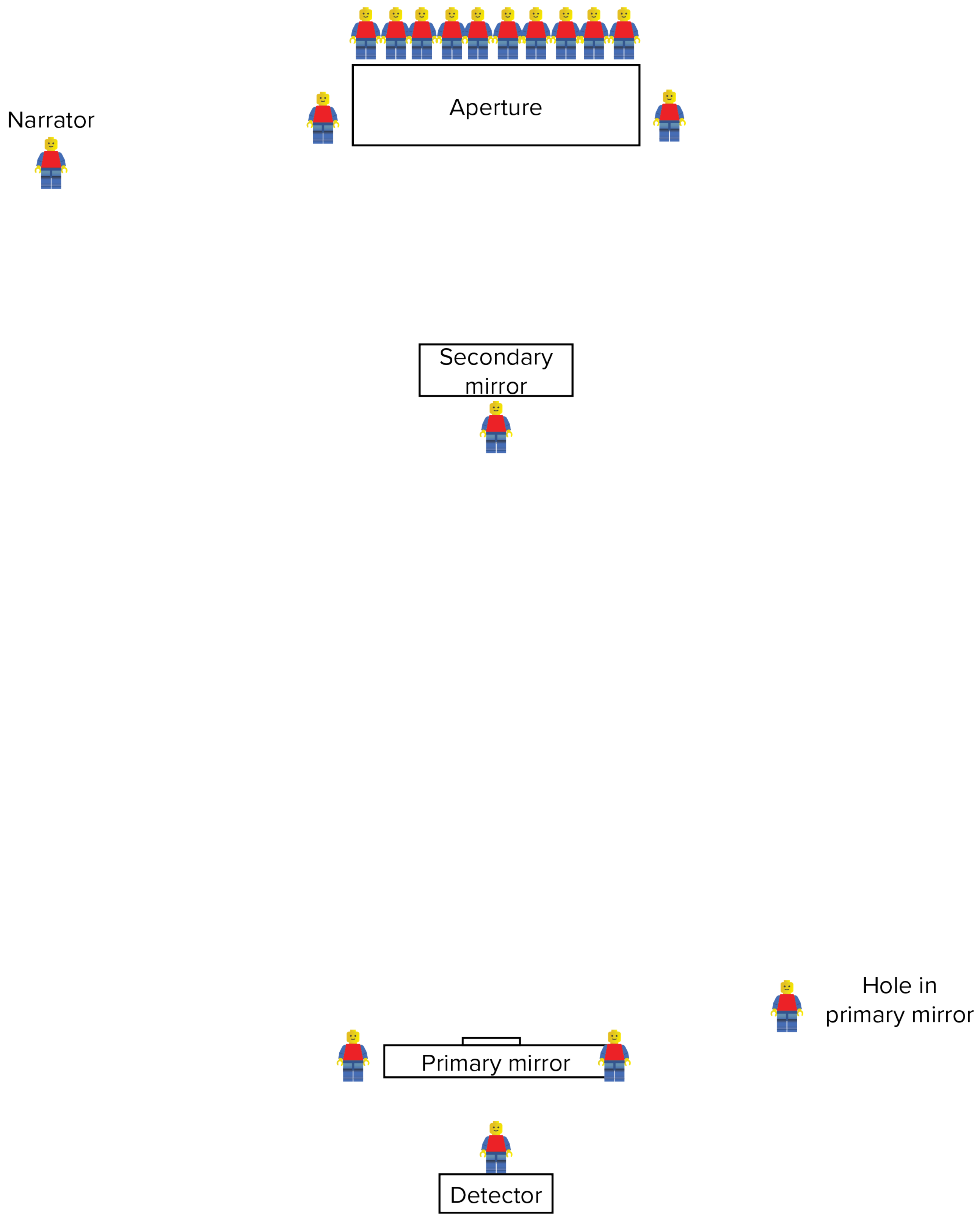
ACTIVITY 2 cont'd

1. Measuring layout



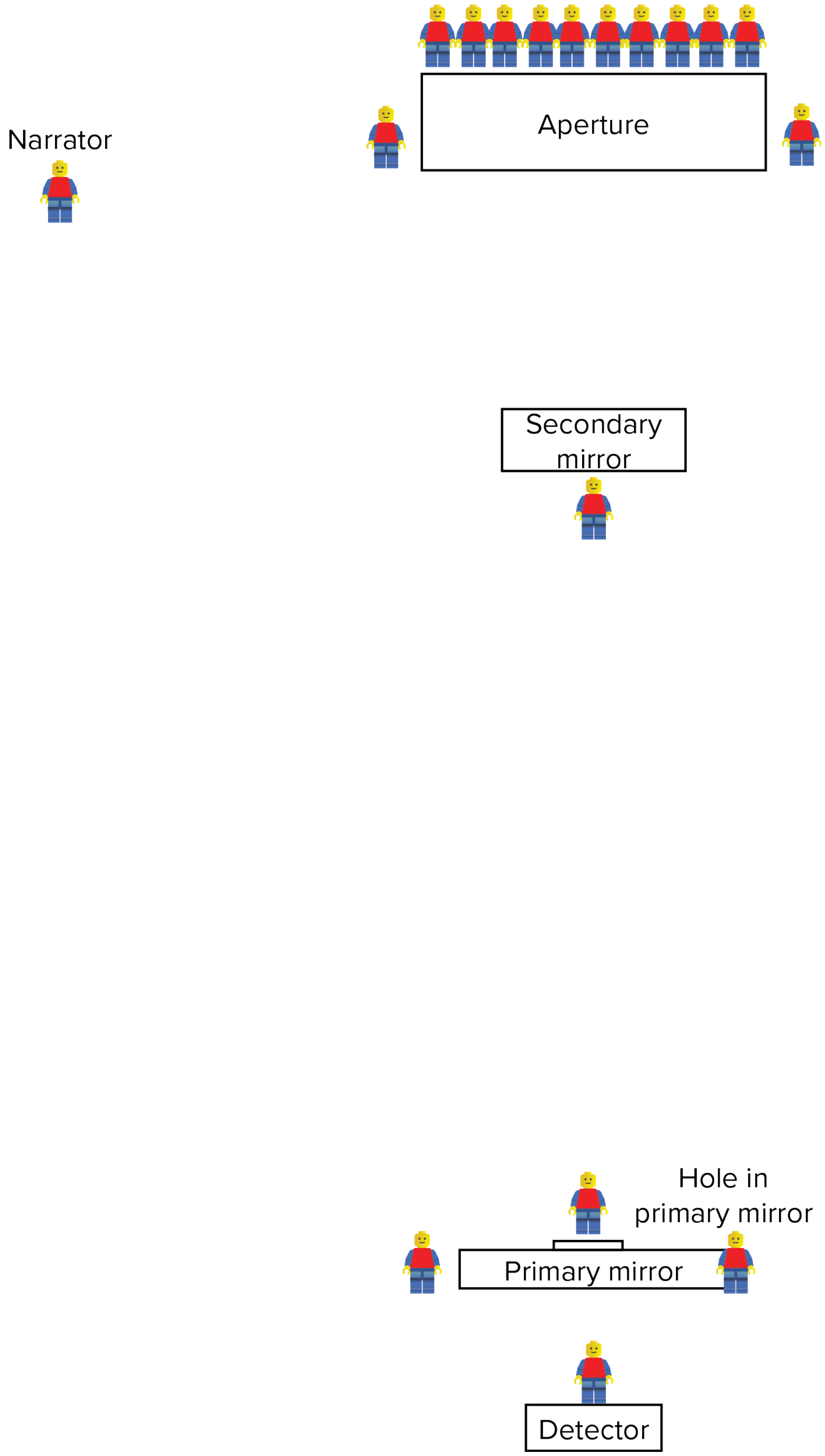
ACTIVITY 2 cont'd

2. Starting layout for all participants.



ACTIVITY 2 cont'd

3. Layout from step 5 of narration.



NARRATION and CARDS - ACTIVITY 2

Narrator's script.

1. Light travels from an object in space through the dome's aperture.

2. Three light 'particles' hit the back of the secondary mirror and are flung out sideways – this light is lost [three light participants now leave the activity].

3. The remaining light 'particles' continue to the primary mirror.

4. The primary mirror collects and focuses the light back onto the secondary mirror.

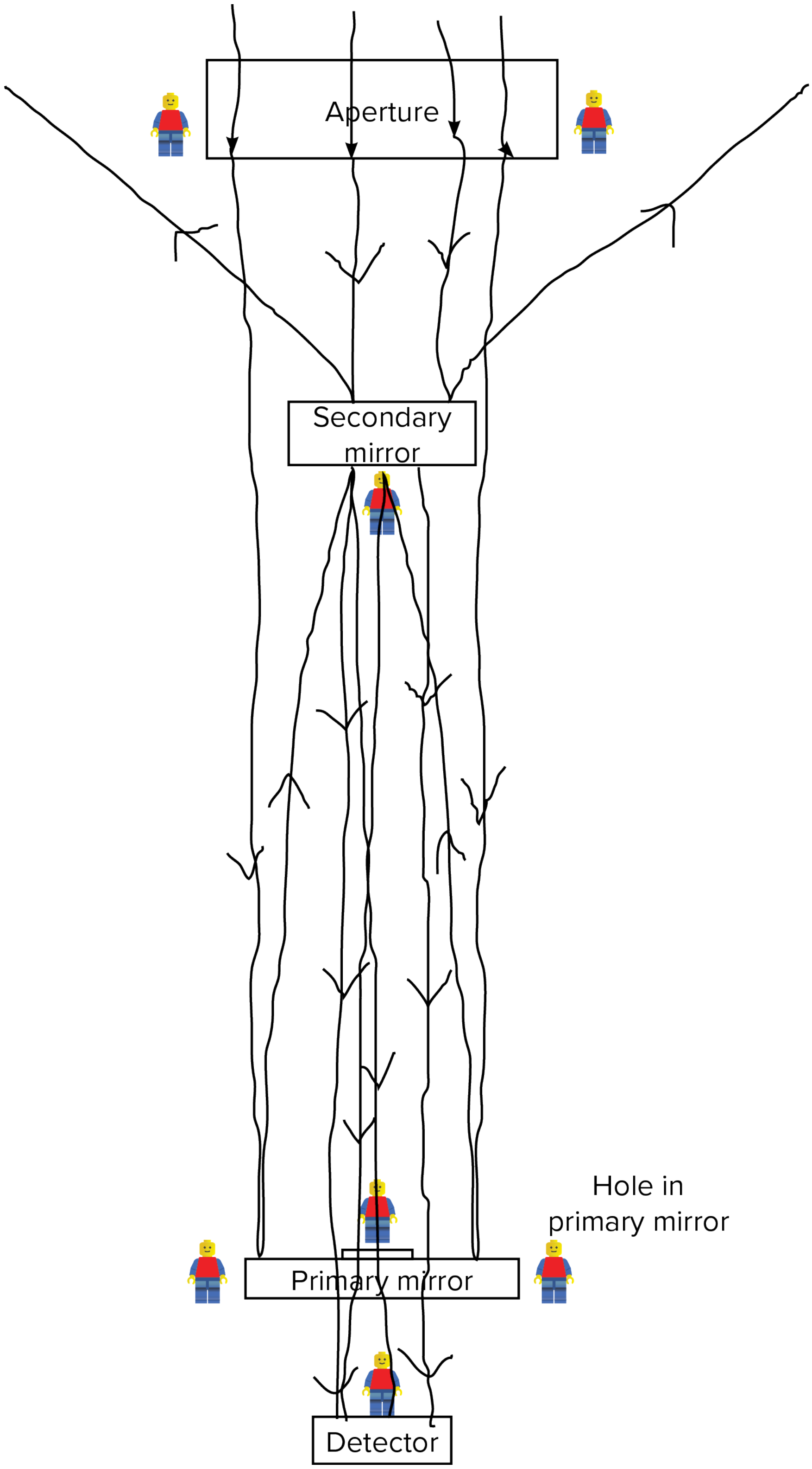
5. The secondary mirror reflects the light down through a hole in the middle of the primary mirror.

6. The detector sees an astronomical image.

		Light
Narrator	**Aperture** The opening of the telescope that lets the light in	**Primary mirror** Focuses light onto secondary mirror
Secondary mirror Focuses light into the detector	**Light**	**Light**
Light	**Light**	**Light**
Hole The channel for the light to travel through	**Detector** 'Sees the image from the telescope	**Light**
Light	**Light**	**Light**

ACTIVITY 2 - WORKBOOK ANSWERS

1. Now that you have completed the exercise, trace out the track that the light particles took in the telescope. Use arrows to show the direction at each step.



ACTIVITY 2 WORKBOOK ANSWERS cont'd

2. What differences do you notice in the two different layouts of telescopes?

The second one needs a hole in the primary mirror. Light is lost. The second one has a detector at the far end; the first one has a detector or eyepiece off to the side. The first one has an aperture that is the same size as the primary mirror; the second one has an aperture that is larger than the primary mirror.

3. Which telescope would collect the most light? Why?

This depends on the size of the obstruction that holds the secondary mirror in place at the top of the telescope, and the size of the hole in the primary mirror. This means that both of those factors are taken into consideration when designing telescopes, i.e. how the secondary mirror is mounted, and the size of the hole.

4. The AAT's primary mirror weighs 120 tonnes. Suggest some issues this might cause when operating the telescope.

Suggestions might include: It's difficult to turn it to point at different objects in the sky. It could bend and deform under its own weight.

5. In this activity the 'light' moved from place to place at a person's walking speed. How fast would it be moving in real life?

The speed of light! Well, more exactly, the speed of light in air, which is 90 kilometres per second SLOWER than in a vacuum.